VIVEKANANDA GLOBAL UNIVERSITY, JAIPUR

FORMAT FOR OUTLINE OF PROPOSED RESEARCH INVESTIGATION FOR Ph.D. DEGREE

(TO BE SUBMITTED BY THE CANDIDATE IN DUPLICATE)

1. **Name of Scholar:** Manish Kumar Gupta

2. **Provisional Registration number (if allotted):** N/A

3. **Title of the Research Investigation (Max. 25 words):**
   Study and analysis of electromagnetic pollution and its effect on human body.
4. **Faculty/Department/Subject:**

   Electronics and Communication Engineering/ Electronics

5. **Objective and Scope of the Research Investigation (Approx. 500 words):**
   (Clearly state and explain your research idea. This may take the form of a hypothesis. Provide a short over view of your proposed research- the key issue(s) that you wish to investigate. Ph.D. is an original piece of research, so you should demonstrate that your proposed topic has not been studied before or you are taking new perspective on the issue.)

   From past years, many research papers are been reported to show the effect of Electromagnetic radiation/tower radiations/microwave radiation/other electromagnetic pollution on human being, other living mammals and even on plants .Almost all papers reported above were experimental studies of effect of these radiations on living bodies. Although these papers were also contradicted time to time by other researchers and all the times it is reported that these so called effects were basically due to another add-ons in practical conditions as mobile phone radiations are un-ionized EM waves and they can not affect living bodies.
   Due to the large number reports and visualized effects of these radiations on living bodies, it has now become important to get the factual knowledge about whether electromagnetic pollution really affect human body, and if yes then up to what extent? We are here proposing for a practical approach to find/establish relation between these radiations and the human body. We are also proposing a survey of the Jaipur, Rajasthan and nearby location to investigate the effect of electromagnetic effect on the local colonies and societies.

Biological and medical studies show that long term impact of cell phone radiations on human body varies with different age group and methods of use of cell phone. Due to the lack of established mathematical/physical relationship of these radiations with human body, it is never cleanly proved that these impacts are exclusively due to cell phone radiations or cell tower radiations. This proposed work is all about the establishment of that missing exact relationship (it there is any, at all) , its appropriateness with biological/medical data available and an another field survey of public of Jaipur about their experiences related to the cell phone radiations and other type of electromagnetic pollution. Our basic idea is to fill the gape available on the physics/mathematical background in the above mentioned arena.

Successful implementation of this work will lead to the transparent state for the concerned that whether Cell phone radiation and other EM pollution really affect us. This work will lead them to explore and cure more details about the particular studies of more focused particular effects of these radiations.

6. Proposed Methodology (Approx. 200 words):

(Identify- how you are going to access the material and possible research methods or techniques that you will use, include some reflection on potential problems that you may face in the research process .Specify the limitation of planned methodology for investigation)

The aim of this thesis is to research and evaluate the spread of electromagnetic radiation emitted by mobile connection antennas and mobile phones.

To reach the aim set in the thesis, it is necessary to tackle the following tasks:

1. To evaluate the spread of electromagnetic radiation, created by the antennas with different overall effective radiated power in the environment.
2. To research the strength of electric field created by the various mobile phone models.
3. To create the strength spread of electric fields of mobile phones around head and provide the evaluation of electromagnetic radiation strength of mobile phone antennas by applying theoretical research.
4. To investigate materials that screen electromagnetic radiation, and to create mobile phone case that reduces the electromagnetic radiation.

The study is proposed in three different independent stages:

Stage 1: First stage is review of available literature related to the problem we have started with. There are some research papers published earlier on the related problems. We have identified two different papers which have shown some algorithms reported to establish the relation of cell phone radiation with human body. We are focusing on the available relations and their validity / modification for the verification with the factual data.

Stage 2: Second stage of the proposed work is to evaluate the EM radiations created by cell phone towers and mobile phone models. Related mathematical model may be obtained in this stage.

Stage 3: Third stage of the work will be the modeling of spread of EM waves in different specific parts of human body. In this stage, we will also predict the theoretical / mathematical concept for the explanation of the occurrence of the effects of these spreading on those specific parts of body.

7. Importance of Proposed Research Investigation/ Expected outcome (Approx. 200 words):

(Establish the relevance and value of proposed research in the context of current academic thinking. Provide in brief why proposed work is important and where outcome of investigation is expected to be used.)

The proposed work is expected to get following outcomes

1. A survey report of local people from Jaipur about their experiences related to effects of cell phone radiations.
2. Relation of the strength of electric field, transmission power of a mobile phone, frequency and dependence on the space, whether it is closed or open.
3. Strength of a mobile phone electric field on the head/skin, its dependence on position and distance of mobile phone from body, dependence on density of constituent parts of the head.
4. Modeling of observed effects in physical/mathematical interpretation.

8. Review of the work related to the field of Research- already done on the subject -Present and Past Status (Approx.200 words):

(Ground your research in existing literature. Reflect some major debates and issues and to show your familiarly with some of the main works addressing the research issues you are proposing- demonstrating your understanding of research issues.)

The world we live in is constantly modernizing and the electromagnetic radiation emitted by electronic devices, electric-power transmissions, television and radio stations, computers, radars, mobile phone antennas and, especially, by mobile phones constantly affect people and can cause various health problems. Electromagnetic waves surround us, however, we are not capable to smell, see or feel them.

In the twenty-first century, with the spread of mobile phone networks and introduction of GSM-900, GSM-1800, UMTS-2100 systems, the number of sources of electromagnetic radiation increased. A lot of people use mobile connection without concerning its operating principles, something that is not seen can cause harm. Active use of mobile phones and their level temporal dynamics allow perceiving the component of electromagnetic background as one of the most important physical agents that actively affect live organisms and environment.

Due to the growing number and scope of sources of electromagnetic radiation from mobile phones, their effect became significant not only for specialist but for all the inhabitants of surrounding areas. In some countries mobile-free zones are demanded. In such zones it is forbidden to install mobile communication base stations, it is also required to reduce the highest levels of allowed electromagnetic radiation or other restrictions are imposed.

When the mobile phone is used, it is put to the ear, and when not – it usually stays in the pocket, near the body, in this way the electromagnetic radiation emitted by (ringing) mobile phone directly interacts with human body. Common mobile phone cases do not provide protection from electromagnetic radiation. Therefore, cases that would protect from electromagnetic radiation, when using mobile phones, and that would not have negative effect on the quality of connection, are necessary. Measurements and evaluation of electromagnetic radiation level, reduction of the highest allowed level of electromagnetic radiation and establishment of other regulations – are issues of world-wide importance. At the moment, the most important concern is the contradictory information about mobile phones and mobile communication base stations, and their declared effects on human health.

On 31st May 2011 the World Health Organization's International Agency for Research on Cancer announced that, when the mobile phone is used for a long time – 30 or more minutes per day, the radiofrequency electromagnetic fields can increase risks of the brain tumor. World Health Organization stresses that when mobile phone is used properly and following all safety measures the negative effects on health caused by electromagnetic radiation can be minimized or avoided.

Due to the lack of scientific researches on electromagnetic radiation from mobile phones and public concern, the tendencies of EMF insensitivity parameters in the environment are discussed in this thesis. The contemporary opinion on the negative effect of mobile phone antennas and electromagnetic radiation from mobile phones does not allow making assumptions about future consequences. Thus, on the basis of conducted scientific research, not only practical but also engineering – technical safety measures from electromagnetic radiation have been provided in this thesis. A rapid increase in the level of electromagnetic radiation (many times exceeding original background) that can damage ecological balance of the environment has been observed; therefore, it should be researched and evaluated by theoretical and experimental methods.

Biological research regarding the potential biological and health effects of EMF has been conducted for decades and it has related to several different biological and health aspects. The studies have been conducted using different frequencies, exposure levels and durations as well as modulation types of RF-EMF. Several research strategies have been applied using epidemiology as well as *in vivo* and *in vitro* methods, since each of these approaches has its own strengths and weaknesses. Specifically, exposure assessment is one of the common challenges concerning all the study approaches in mobile phone radiation research. Epidemiological studies aim to demonstrate a direct impact on humans and are thus usually considered to be the most suitable for human health risk assessment, which is an important issue in mobile phone radiation research.

However, epidemiological studies in mobile phone radiation research are often limited by the assessment of exposure. In the studies executed so far, exposure assessment has often been carried out using questionnaires on mobile phone use completed by study participants. This might potentially cause bias in exposure assessment, e.g., due to recall bias. Human volunteer studies also provide direct evidence of the actual human response, but due to ethical reasons, these studies are limited to transient physiological phenomena. Studies *in vivo* can be used to mimic human studies to obtain physiological information in experimental situations where it is not possible to use human volunteers. Studies *in vitro* are extremely useful for determining basic biological effects and potential mechanisms behind the effects, while they cannot be directly applied in health risk assessment.

In some of the early studies *in vivo* and *in vitro*, estimation of the exposure has been challenging, as the samples might have been heated to excess due to the RF-EMF exposure. Thus, it is unclear whether the effects potentially observed in these studies have been caused by heating or RF-EMF exposure (i.e., whether those are non-thermal effects). Furthermore, in certain studies the exposures have been executed by placing a regular mobile phone close to an animal cage or cell culture dishes. Such exposures do not allow reliable exposure assessment. Nowadays, specific exposure set-ups have been designed for studies both *in vivo* and *in vitro*. In the most optimized set-ups the study subjects are exposed to RF-EMF in a highly controlled environment and several

factors such as temperature and field parameters can be monitored continuously during the exposure.

Cancer-related studies

One of the most common fears regarding mobile phone radiation exposure has been its potential ability to cause cancer. The cancer incidence due to mobile phone radiation exposure has been examined with epidemiological studies that examine the direct influence on humans. Additionally, effects on the incidence of cancer have been examined using animal studies. Epidemiology provides the most direct evidence of the carcinogenic potential of specific agents in humans. Therefore, several epidemiological studies have examined the effects of mobile phone use on tumor formation. By far the most common area of focus has been on tumors of the head and neck area (e.g., gliomas, meningiomas, acoustic neuromas, and salivary gland tumors). Most of the completed epidemiological studies regarding mobile phone use and cancer incidence have been case-control studies, whereas only a few cohort studies have been performed. In case-control studies a patient with a diagnosed disease is asked to participate in the study, and after the permission is granted, he/she is often interviewed. Additionally a respective control person is sought for the study. Exposure assessment is based on either interviews or records from mobile phone network operators. If the exposure assessment is based on interviews, recall bias (i.e., how well the study person recalls the duration of phone calls, the location where the phone was held, etc.) may significantly affect the findings. The most recent large epidemiological study on mobile phone use and tumor risk has been the INTERPHONE study, which included over 5000 brain tumor cases with respective controls in 13 different countries (INTERPHONE Study Group 2010). The research group concluded that no overall increased risk of glioma or meningioma was observed due to mobile phone use. However, the research group observed some indications of an increased risk of glioma at the highest exposure levels (long-term heavy usage), but biases, such as recall bias, and error prevented a causal interpretation. Several expert groups currently conclude that overall the studies published so far do not demonstrate a raised risk within approximately ten years of mobile phone use for brain tumors or any other head tumors. However, for slow-growing tumors the latency period is still too short to draw conclusions (e.g., International Commission for Non-Ionizing Radiation Protection (ICNIRP) 2009). Recently, a new cohort study (COSMOS) was launched in five countries to examine health risks related to long-term mobile phone use (Schuz et al. 2011) according to high priority research needs identified by the World Health Organization (WHO) (World Health Organization (WHO) 2010).

Animal studies have also been used to examine the incidence of cancer in relation to mobile phone radiation exposure. For instance, Repacholi et al. exposed transgenic mice to 900 MHz pulsed wave (PW) SAR values ranging from 0.008 to 4.2 W/kg and examined incidence of lymphoma (Repacholi et al. 1997). In this study, the lymphoma incidence increased after exposure and the authors reported that PW could enhance lymphoma formation in genetically cancer-prone mice. Subsequently, the study of Repacholi et al. was replicated by Utteridge et al. (Utteridge et al. 2002) and Oberto et al. (Oberto et al. 2007), but no increased lymphoma incidence was found. In several other studies, in which genetically wild type mouse strains have been exposed to mobile phone radiation, no increased tumor incidence has been detected (e.g., La Regina et al. 2003, Tillmann et al. 2007). Animal studies have also been used to examine whether mobile phone radiation could enhance the carcinogenicity of other agents. For example, Tillmann et al. recently exposed mice lifelong to the UMTS signal in the presence of known carcinogen and reported a doubled rate of lung cancers in the treated group when compared to the controls (Tillmann et al. 2010). The authors of this pilot study suggested that the UMTS signal might be potentially cocarcinogenic. Nonetheless, most published studies have not reported potential epigenetic carcinogenicity of mobile phone radiation (e.g.,
Heikkinen et al. 2006).

Human volunteer studies

Human volunteer studies can provide direct evidence of the actual human response, and several human volunteer studies have therefore been performed regarding mobile phone radiation exposure. However, due to ethical reasons, the endpoints in human volunteer studies are limited to transient physiological phenomena, such as nervous and endocrine system function or thermoregulation. Other endpoints include effects on sleep quality and symptoms of illness such as headaches. Nervous system studies have included, for instance, behavioral and neuro-pysiological measurements. These have recently been reviewed, among others, by van Rongen et al. and Kwon and Hamalainen (van Rongen et al. 2009, Kwon, Hamalainen 2011). A few positive findings have been reported in early behavioral studies, e.g., improved learning after mobile phone radiation exposure. Nevertheless, these findings have not been reproduced in later larger studies, even though these studies might have been performed by the same research groups (e.g., Koivisto et al. 2000a, 2000b vs. Haarala et al. 2003a, 2003b, 2004). Potential reasons for the diverse results could be the better experimental design in later studies, i.e., more study subjects, double blinding, and better control for false positives in statistical analysis.

Sleep quality has been examined in relation to mobile phone radiation exposure. Certain results suggest that mobile phone exposure has an effect on sleep electroencephalography (EEG) by increasing the EEG alpha range in the sleep EEG (e.g., Lowden et al. 2011). However, several other studies have found no effects on other sleep quality parameters (e.g., Fritzer et al. 2007 Mohler et al. 2010). Volkow et al. exposed human volunteers to mobile phone radiation and investigated brain glucose metabolism using positron emission tomography (Volkow et al. 2011). A minor, but statistically significant, increase in brain glucose metabolism in the brain regions closest to mobile phone was reported after the exposure. Recently, Kwon et al. applied similar type of research approach as Volkow et al. (Kwon et al. 2011a, 2011b). No effects were found on cerebral blood flow, while brain glucose metabolism was suppressed after mobile phone radiate on exposure. However, it is unknown whether changes in brain glucose metabolism have any clinical significance.

Some human studies *in vivo* on genotoxicity have also been performed. For example, Gandhi and Anita reported an increase in chromosomal damage when comparing mobile phone users and never-users, but the results were indicated as preliminary (Gandhi, Anita 2005). Yadav et al. reported an increased frequency of micronuclei in cells exfoliated from the human oral cavity of mobile phone users in comparison to controls (Yadav, Sharma 2008). The authors also reported a correlation between the years of exposure. Hintzsche and Stopper used a similar type of study set-up to Yadav et al. but found no differences related to mobile phone use (Hintzsche, Stopper 2010). Thus, no conclusions can yet be drawn on human genotoxicity studies. Additionally, Karinen et al. have examined molecular responses in human skin *in vivo* (Karinen et al. 2008).

Physiological endpoints in animal studies

In addition to cancer incidence (section 2.1.3.2), other biological and physiological endpoints have also been studied *in vivo* after mobile phone radiation exposure. Either rats or mice have most commonly been used in these experiments, but some studies have also used rabbits or flies (*Drosophila melanogaster*) as study subjects.

One of the interesting endpoints related to mobile phone radiation exposure has been the blood-brain barrier (BBB) and potential leakages in it. Possible leakages in the BBB may allow molecules of the blood circulation to enter the cerebrospinal fluid, causing potentially harmful effects. Some studies have indicated that mobile phone radiation might have an effect on BBB permeability. For example, Salford et al. reported an increase in the permeability of the blood-brain barrier to albumin after a two-hour exposure to a GSM signal (SARs 2 mW/kg, 20 mW/kg, and 200 mW/kg) (Salford et al. 2003). It was also suggested to cause neuronal damage

throughout the brain, especially in the cortex, hippocampus, and basal ganglia. However, no effects on the BBB have been observed in replications of the Salford et al. study (de Gannes et al. 2009, Masuda et al. 2009). In addition, several other studies have reported no effects on the BBB (e.g., Finnie et al. 2006a). Therefore, based on the current scientific evidence, the effects on the BBB following mobile phone radiation exposure remain controversial, but seem very improbable.
Other brain areas and functions have also been examined after mobile phone radiation exposure. Recently, for example, Finnie et al. found no evidence of microglial activation (Finnie et al. 2010). In their study, they observed no perturbation of the neural tissue after acute (60 min) or long-term (2 years) exposure of mice using 900 MHz GSM with a whole body SAR of 4.0 W/kg. However, Maskey et al. reported hippocampus damage in rodents after a few months of exposure to an 835 MHz CDMA signal with an SAR range of 1.6 to 4.0 W/kg (Maskey et al. 2010a, 2010b).
Reproduction, fertility, and postnatal juveniles have recently been a concern related to RF-EMF exposure, as juveniles are subjected to a long-term exposure over their life time. At present, it is known that exposure to thermal levels of RF-EMF has a harmful impact on pregnancies and fertility (International Commission for Non-Ionizing Radiation Protection (ICNIRP) 2009). Meanwhile, the number of studies on the non-thermal level of exposure is limited, and no consistent non-thermal effects have yet been reported. For instance, Lee HJ et al. recently exposed rats to a CDMA signal at a SAR of 2 W/kg and found no effects on spermatogenesis in rats after a subchronic exposure (Lee et al. 2010). However, a few human studies *in vitro* have presented contradictory evidence (Falzone et al. 2008, 2011). Fragopoulou et al. recently detected cranial and postcranial skeletal variations induced in mouse embryos after exposure to a commercial mobile phone (Fragopoulou, Koussoulakos & Margaritis 2010), whereas Kumlin et al., for instance, observed no morphological changes in juvenile rats (Kumlin et al. 2007). In the study by Kumlin et al., animals exposed to mobile phone radiation showed significantly improved performance in a water maze task when compared to sham-exposed animals, indicating improved learning and memory (Kumlin et al. 2007). In general, results related to reproduction and postnatal development after mobile phone radiation exposure are still sparse and, for instance, WHO has recommended studies in this field as a high priority research need (World Health Organization (WHO) 2010).
Several other physiological endpoints related to, for example, nervous, auditory, endocrine, and cardiovascular systems, and different organs have also been investigated (for a review, see e.g., International Commission for Non-Ionizing Radiation Protection (ICNIRP) 2009). Recently, for instance, Bartsch et al. examined health effects at the general level in several rat studies *in vivo* after chronic exposure to a GSM-like signal (Bartsch et al. 2010). They suggested that the chronic exposure may incur negative health effects and shorten the life span of the animals if the treatment time is sufficiently long and the observational period covers the full life span of the animals. Meanwhile, Jin et al. reported that a one-year simultaneous CDMA/WCDMA chronic exposure at a SAR of 2.0 W/kg did not increase chronic illnesses in rats, although there were so me altered parameters in the complete blood count and serum chemistry (Jin et al. 2011).

Genotoxicity

Genetic effects after mobile phone radiation exposure have been widely studied. The potential presence of genotoxic effects might lead to tumor formation in the future. Several techniques have been used, such as the detection of chromosomal aberrations, sister chromatid exchanges, and micronuclei, as well as the comet assay and γ-H2AX phosphorylated histone assays. Studies both *in vivo* and *in vitro* have on this topic been published. Most of the published genotoxicity results have not reported effects. Nevertheless, some results remain contradictory (for a review, see e.g., Verschaeve 2009, Verschaeve et al. 2010). The potential genotoxicity of RF-EMF has been studied with animals, mainly with mice or rats. For instance, in the mid-1990s, Lai and

Singh reported that a pulsed 2450 MHz RF-EMF has genotoxic potential. The authors found that the number of DNA single- and double-strand breaks increased in rat brain cells after 2 hours of exposure. The effects were reported immediately after the exposure and four hours after 0.6 and 1.2 W/kg exposures *in vivo* (Lai, Singh 1995, 1996, 1997). However, neither replication studies (Malyapa et al. 1998, Lagroye et al. 2004) nor studies using GSM exposures (Belyaev et al. 2006) have reported similar results. Furthermore, long-term exposures of mice to GSM signals have not caused increased micronuclei frequencies (e.g., Juutilainen et al. 2007, Ziemann et al. 2009). In summary, most of the animal studies have not reported direct genotoxic effects after RF-EMF exposure at non-thermal levels (International Commission for Non-Ionizing Radiation Protection (ICNIRP) 2009).

Genotoxicity has been examined *in vitro* using several different techniques. The majority of studies have not reported effects after mobile phone radiation exposure, while a few positive results concerning rather severe chromosomal effects after mobile phone radiation exposure have also been reported. For example, Tice et al. exposed human leukocytes and lymphocytes to several different mobile phone radiofrequency signals at various SAR levels (Tice et al. 2002). They reported micronuclear changes after a 24-hour exposure with all applied RF technologies at SAR averages of 5 or 10 W/kg in human lymphocytes, but not in leukocytes. After a shorter exposure time of 3 hours, no effects were observed. Using a continuous wave (CW) exposure, Mashevich et al. and Mazor et al. reported increased chromosomal aneuploidy (Mashevich et al. 2003, Mazor et al. 2008). These studies were recently repeated in part by Bourthoumieu et al. (Bourthoumieu et al. 2010, 2011). They examined the cytogenetic effects of 900 MHz mobile phone radiation on cultured amniotic cells and found no significant change in the rate of aneuploidy of chromosomes 11 and 17 or other direct cytogenetic effects. However, the exposure conditions (duration of exposure and SAR levels) were not identical. Several other studies *in vitro* have also reported no genotoxic effects (e.g., Vijayalaxmi et al. 2001a, 2001b, McNamee et al. 2002, 2003, Zeni et al. 2003, 2005, 2008, Scarfi et al. 2006, for review, see e.g., Verschaeve et al. 2010).

Many comet assay studies examining DNA damage and repair *in vitro* have also been published. Recently, an Italian research group reported that modulated GSM signals induced a significant increase in comet parameters in trophoblast cells after a 16- and 24-hour exposure at an SAR level of 2 W/kg (Franzellitti et al. 2010), while CW exposure did not. The changes were reversible after 2 hours of recovery. After shorter exposure times, no effects were observed (Valbonesi et al. 2008). Changes in the comet assay after mobile phone exposure have also been published by an Austrian research group (Diem et al. 2005, Schwarz et al. 2008). DNA strand breaks were already reported at low SAR levels in human fibroblasts. However, results of these studies have been criticized, and using the same study design the results have been negative elsewhere (Speit, Schutz & Hoffmann 2007). Most studies using the comet assay to assess DNA damage and repair have not reported any alterations in these after mobile phone radiation exposure (e.g., McNamee et al. 2002, 2003, Hook et al. 2004, Zeni et al. 2005, 2008, for review, see e.g., Verschaeve et al. 2010).DNA strand breaks can also be examined with a γ-H2AX phosphorylated histone assay, which is currently considered to be the most sensitive method for detecting DNA damages. So far, the method has not been widely used in mobile phone radiation research. Recently, for example, Belyaev et al. applied the γ-H2AX technique to study effects on human lymphocytes using exposures at different frequencies, signal modulations, and at an average SAR of 0.4 W/kg (Belyaev et al. 2009). The results suggested a long-lasting inhibition in the formation of DNA double-strand breaks co-localizing the 53BP1/γ-H2AX DNA repair foci. The effect was suggested to depend on the carrier frequency, with the UMTS signal being more effective than the GSM signal. Additionally, the genotoxicity of the mobile phone radiation has been studied in the presence of known mutagens. Recently, for example, Luukkonen et al. (Luukkonen, Juutilainen & Naarala 2010) and Sannino et al. (Sannino et al. 2009a) examined the combined

effects of mobile phone radiation and a known chemical mutagen using the comet assay. Chemical treatment with the mutagen led to the induction of DNA damage, but no additional DNA damage was observed when mobile phone radiation exposure was also applied. However, another micronuclei assay study by Sannino et al. (Sannino et al. 2009b) reported an adaptive response in human lymphocytes caused by pre-exposure to 900 MHz mobile phone radiation before chemical mutagen treatment. The lymphocytes for the study were collected from different donors, and lymphocytes from only some donors responded adaptively.

Cellular effects

Different cellular effects have also been examined after mobile phone radiation exposure. The potential differences in cellular behavior might play a role, for instance, in later tumor development. These cellular effects include proliferation, differentiation, apoptosis, and transformation, as well as the expression of specific genes and proteins (section 2.1.4). Cellular growth has been examined with several methods. Recently, for instance, Lee KY et al. found no differences in cell cycle distribution after exposure *in vitro* to the CDMA/WCDMA signal for one hour at an SAR level of 4 W/kg (Lee et al. 2011). Sekijama et al. exposed three different cell types to the WCDMA signal with different durations up to 96 hours and the SAR averages up to 0.8 W/kg and found no differences in cell growth (Sekijima et al. 2010). The ornithin decarboxylase (ODC) expression levels have also been assessed, since the enzyme is involved in cell growth and its overexpression might regulate, for instance, cancer invasiveness. In the mid-1990s, increased ODC activity was reported after exposure *in vitro* to various frequencies and modulations of RF-EMF (Litovitz et al. 1993, Penafiel et al. 1997). The increased activity was suggested to be exposure time-, frequency- and modulation-specific, peaking at certain points (the so-called 'window effect'). These studies have since been replicated, but no increase in ODC activity has been observed (Desta, Owen & Cress 2003, Hoyto, Juutilainen & Naarala 2007). However, it has been reported that ODC activity is sensitive even to small temperature change (Hoyto et al. 2006), which could have been caused by mobile phone radiation exposure in the original study set-up. A few studies have also reported effects on cell proliferation after mobile phone radiation exposure (e.g., Velizarov, Raskmark & Kwee 1999), whereas several others have not shown effects on cell proliferation or viability (e.g., Nikolova et al. 2005, Gurisik et al. 2006, Merola et al. 2006, Sanchez et al. 2006, Chauhan et al. 2007a, Huang et al. 2008a, 2008b).

Cellular apoptosis is an important process in which mutated or otherwise damaged cells are guided to 'commit suicide' and thus be eliminated from the tissue. The effects of mobile phone radiation exposure on cellular apoptosis have been examined in several studies. For instance, Buttiglione et al. exposed a human neuroblastoma cell line to a 900 MHz PW at a mean SAR level of 1 W/kg. After 24 hours the authors reported an increase in apoptosis and also a decrease in known apoptosis inhibitor genes BCL-2 and survivin at the mRNA level (Buttiglione et al. 2007). Caraglia et al. also reported an increase in cellular apoptosis as well as changes in apoptosis-related genes after a 3-hour exposure to the 1950 MHz RF-EMF at an SAR level of 3.6 W/kg (Caraglia et al. 2005).

However, most studies examining apoptosis after mobile phone exposure have not reported any changes (e.g., Gurisik et al. 2006, Joubert et al. 2006, 2007, Lantow et al. 2006c, Merola et al. 2006, Falzone et al. 2010). Cellular transformation has been examined to determine whether the RF-EMF exposure could act as an inducer or a promoter of tumor formation or as a potential cocarcinogen. In the 1980s, Balcer-Kubiczek and Harrison reported that cellular transformation was increased in the presence of a known carcinogen after RF-EMF exposure (Balcer-Kubiczek, Harrison 1985, 1989, 1991). However, several newer studies have failed to support this observation. For example, Hirose et al. found no evidence of cellular transformation using the same cells as Balcer-Kubiczek and Harrison and a 2142.5 MHz WCDMA exposure (Hirose et al. 2008). One potential mechanism that has been proposed for RF-EMF-associated effects is the

ROS-mediated mechanism. ROS formation after the mobile phone exposure has consequently been examined in a few studies. Most of these have not reported any effects on ROS production after mobile phone radiation exposure alone or in combination with known chemical agents (e.g., Lantow et al. 2006a, Brescia et al. 2009, Falzone et al. 2010, Luukkonen, Juutilainen & Naarala 2010). Thus, the current data suggest that mobile phone radiation exposure has no effect on ROS production in several different cell lines (International Commission for Non-Ionizing Radiation Protection (ICNIRP) 2009).

9. Research Gaps identified in the proposed field of investigation - Based on review (Approx. 100 words):

(Identify existing gaps – both Theoretical and Practical that your research is intended to address.)

There were several papers reporting past years about the effect of mobile tower radiations in Jaipur. It was a prime time news that time in leading local news papers. There is still a need from research point of view to conduct a proper survey in the local area to collect the data about these effects experienced by the people. This is the first gap we found and being covered in our proposal.

Though, there are number of papers reporting about the health issued related to EM pollution but there is still no proper mechanism to define why these affects are occurring, and even more, we are not able to prove that these effects are exclusively due to the radiations only. We are proposing to model these effects and their dependence on EM fields. We have proposed to use COMSOL Multiphysics for the purpose of modeling and simulation of the above said gap. Another platform may be used for the counter verification on the basis of the availability and accessibility of the gadgets.

The theoretical/mathematical verification is also be done for the proposed work. If once it is verified, it will be great add-on to the medical and the biological researchers as if they know the exact mechanism oh happening of these effects, they may further plan to cure the same.

10. Chapter wise details of Proposed Research Investigation Ph.D. Thesis:

(Title of each chapter along with expected contents must be prepared in advance. It should be concise and unambiguous.)

Chapter 1: Introduction
Chapter 2: Effect of EM Radiations: Literature Review
Chapter 3: EM Radiation by Cell Phone Towers/Cell Phones used in India.
Chapter 4: Effect of Cell phone radiation in Jaipur: A survey
Chapter 5: Mathematical model for EM Radiation analysis
Chapter 6: Simulations and Results
Chapter 7: Conclusion and Future Scope
References

11. Expected duration of the investigation (Year wise schedule to be given):

(Provide a realistic time plan for completing your research degree. Demonstrate that your research will not take longer than planed time.)

Total Expected Duration: 2 Years (Excluding course work)

Semester Wise Pert Chart is attached with the Synopsis (Annexure- 1)

12. Facilities available for the investigation at scholar end and facilities required on campus:

Required/Available facilities on Campus:

1. COMSOL Multiphysics software
2. MATLAB and MATHEMATICA / MAPLE tool
3. SPSS software
4. Freedom to conduct field survey(s)
5. Access to leading journals

13. Bibliography- At least 50 relevant references (Update):

(It is unlikely that you can review all the relevant literature at this stage but you should be able to reflect issues you have proposed for investigation and work done/in progress by other workers on related issues.)

1. Reetta Nylund, "Proteomics analysis of human endothelial cells after short-term exposure to mobile phone radiation", Doctoral Dissertation, Aalto University School of Science, 2011
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